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Household wealth accumulation and portfolio choices in Korea

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ABSTRACT

This paper constructs a quantitative lifecycle model with uninsurable labor income and housing return risk to investigate how Korean households make saving and portfolio decisions. The model not only incorporates the special roles housing plays in the portfolio of households: collateral, a source of service flows, as well as a source of potential capital gains or losses, but also adds to existing models of wealth accumulation some unique institutional features present in Korea, namely the rental system ('chonsae') and the lack of a mortgage system. When the model is calibrated to match the Korean economy, several key features of the data are better able to be reproduced. The paper also analyzes the role of institutional features by comparing several alternative housing market arrangements to assess their impact on wealth accumulation, portfolio choices, and homeownership. A 10 percentage points reduction in down-payment requirement is associated with approximately 1 percentage point increase in the aggregate homeownership ratio in Korea. Lower down-payment also increases the fraction of aggregate wealth held in housing assets but lowers aggregate net worth with mixed demographic implications.

1. Introduction

In this paper, we examine the Korean household wealth accumulation and asset portfolio choices over the lifecycle. Empirical studies about household portfolios have been undertaken in some developed countries, but little attention has been paid to developing countries mainly due to the lack of quality data. We use the recent Korea Labor Income Panel Study (KLIPS) from 1999 to 2005 to examine how average Korean households accumulate their wealth over the lifecycle.

Housing is the most important form of wealth in Korea. According to the KLIPS data, while approximately 58% of households are homeowners, housing assets make up more than 60% of total net worth held by all households. The share of financial assets, on the other hand, is important for younger households (60% of net worth for age groups 25–34) but remains low for all other households. Thus, despite a low homeownership ratio in Korea housing is the most predominant source of wealth. This also indicates that the decision to purchase a house has important implications for the portfolio composition of a Korean household over the lifecycle, as housing not only provides a flow of service for consumption but also can be used as a source of investment.

Unique to the Korean economy is the existence of the 'chonsae' rental system, in which a tenant pays an upfront deposit upfront upon entering the rental contract, with no additional periodic rent payments. The deposit is usually 40–80% of the property value. The tenant receives the nominal value of the deposit from the landlord upon expiration of the contract, which typically lasts 2 years. Landlords earn interest income from the deposit or use it for other investment purposes. According to Ambrose and Kim (2003), the wide prevalence of the chonsae system is partly attributed to the underdeveloped financial sector

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and heavy government intervention during the period of high growth in Korea. Government policy set low interest rates for business loans, with this cross-subsidized by households by virtue of banks being "allowed" to charge high interest rates for consumer credit and housing finance. Historically, the chonsae system provided a source of funds landlords while providing affordable housing options for renters who did not have enough cash to purchase a house (Kim, 2004).

Another aspect of the Korean economy is the lack of long-term mortgage contract, which reflects the underdeveloped nature of the financial sector in Korea. For instance, Lam (2002) reports the average mortgage to GDP ratio in Korea between 1996 and 2000 to be around 11% and the average loan-to-value ratio to be 28%.[2] A full-scale government-endorsed mortgage system was only introduced in 2004, prior to which such a system was almost non-existent.

Allowing for these specific housing features in Korea, we set up a partial equilibrium lifecycle model and calibrate it to match wealth accumulation and portfolio choice over the lifecycle. In the model, housing plays multiple roles as not only a source of direct consumption but also as an investment with potential for capital gains and collateral. The results from the calibrated model applied to the Korean economy can quantitatively explain some empirical findings on the profile of wealth and homeownership in the aggregate as well as over the lifecycle.

We then assess the roles played by the institutional features of the mortgage market and the rental market arrangement, and ask how much they can account for the observed pattern of the wealth accumulation and portfolio composition in Korea. For the mortgage market, an expansion of the current mortgage system is represented by a higher loan-to-value (LTV) ratio, which relaxes collateral constraint. Expanding the current mortgage system increases the homeownership ratio and the fraction of wealth invested into housing assets, while lowering the overall level of wealth accumulation in the economy. For reasonable parameter values, I find that increasing the LTV ratio by 10 percentage points is associated with approximately 1 percentage point increase in the homeownership ratio and 0.25% decrease in the average net worth. A lower wealth accumulation in the economy is caused by the shift in the average wealth portfolio toward housing wealth, which yields a lower average return than financial wealth. Demographic implications are mixed with larger changes in the homeownership among the younger and the retired age cohorts. Specifically, homeownership ratios for the cohorts aged 35–44 and 75–83 increase by 1.9 and 2.5 percentage points, respectively, for every 10 percentage points increase in the LTV ratio.

Next, the rental arrangement in the benchmark model is altered such that in lieu of a lump-sum chonsae deposit, households pay periodic rental payment which is assumed to be a fraction of the house value. With the annual rental cost being approximately 2.4% of the house value, our counter-factual policy experiment results in a decrease in the overall level of wealth accumulation and the homeownership ratio, with the latter implying that renting becomes a cheaper alternative to homeownership and lowers the need for savings geared toward housing purchase. Quantitatively, the aggregate net worth and the homeownership ratio decline by 3.4% and 7.8 percentage points, respectively. As for age demographics, the homeownership ratio for the age cohort of 55–64 is 4.1 percentage points lower than the benchmark, and after retirement, households switch back to renting more quickly as the homeownership ratio declines by 25 percentage points for the age cohort of 65–74, compared to 11.6 percentage points decline under the benchmark scenario.

This paper builds on the emerging literature that document household portfolio allocation. With a few papers allowing for housing in models of portfolio choice, the role of housing wealth has received greater attention due to its unique role: people can borrow against housing; housing is indivisible and relatively illiquid (buying and selling entail significant liquidation costs); and housing not only provides a flow of real consumption benefits to the owner, but also, acts as an investment good that provides potential for capital gains or losses. Grossman and Laroque (1990), using an infinite horizon model, are the first to analyze housing in the portfolio allocation in the presence of adjustment costs. Díaz and Luengo-Prado (forthcoming) and Gruber and Martin (2003) also use a standard infinite horizon model to study the role of durable goods and collateral credit in accounting for wealth inequality and the level of precautionary savings in the United States. Cocco (2005) specifies the housing price risk to study the asset allocation decision in the presence of housing. Some papers explicitly include housing in the context of a general equilibrium lifecycle framework. For example, Silos (2007) investigates the wealth distribution while incorporating different housing tenure choice, while Chambers et al. (2009) examine the recent changes in the US homeownership ratio and introduce exogenous *iid* shock to the capital gains from housing transaction. Additionally, an alternative to the housing market is that people can rent instead of purchasing a house. In the case of renting, renters receive a similar flow of services, although somewhat less than from their own house, and are not subject to capital gains or losses. Platania and Schlagenhauf (2002), Ortalo-Magné and Rady (2002), Ortalo-Magné and Rady (2006), Hu (2005), Yao and Zhang (2005), Li and Yao (2007), and Yang (2009) all incorporate the rental vs. homeownership decision into their models. A good literature review on macroeconomic models with housing is provided by Jeske (2005).

In general, models of housing have made predictions closer to what have been observed empirically in areas such as wealth distribution, household portfolio allocations, and tenure decisions. This paper evaluates the predictions of these models on the Korean economy while incorporating its unique housing market features. This will help to examine the role of these features in accounting for the wealth accumulation and portfolio choice as well as providing country-specific groundwork for various policy analyses.

[2] The analogous numbers for the United States were 55% and 80%, respectively.

Table 1
Summary statistics wealth.

	Average	Median	Top 20%	Bottom 20%
Net worth (1) + (2) – (3)	5.12	2.75	7.32	0.61
Housing asset (1)	3.15	1.55	5.22	0.00
Non-housing asset (2)	2.96	0.96	3.52	0.03
Rent deposit	0.48	0.00	0.90	0.00
Bank deposit	0.52	0.06	0.63	0.00
Stock and bond	0.07	0.00	0.00	0.00
Other financial assets	0.14	0.00	0.07	0.00
Non-financial assets	1.75	0.00	1.27	0.00
Liabilities (3)	0.99	0.05	1.20	0.00
House to net worth ratio	61.0%	46.7%		
Rent deposit to non-housing asset ratio	24.7%			

The rest of this paper is organized as follows. Section 2 presents some empirical findings from the KLIPS data and documents some stylized features of wealth accumulation and portfolio. Section 3 describes the lifecycle model framework. Section 4 outlines the calibration and the parametrization of the model. In Section 5, benchmark simulation results are presented and quantitative policy experiments are undertaken. Section 6 conducts a sensitivity analysis on the choice of some parameter values and discusses the cost and benefit of owning vs. renting, and concluding remarks are provided in Section 7.

2. Data and empirical evidence

2.1. Wealth statistics

In this study, we use the Korean Labor Income Panel Study (KLIPS) from 1999 to 2005. It is a socio-demographic panel study which includes data about household income and wealth. In the wealth category, the KLIPS survey asks households about various types of assets and liabilities. Net worth is defined as the difference between total assets and liabilities. Total assets are grouped into primary value of owner-occupied housing (“Housing asset”) vs. all financial assets including chonsae rent deposits, bank deposits – checking and savings account, stocks and bonds, as well as other non-financial assets such as secondary home, land, and rental real estate (“Non-housing asset”). Since renters in Korea pay an upfront deposit at the beginning of the contract and receive the exact nominal amount at the end of the contract, chonsae rent deposits are considered a financial instrument with a zero nominal interest rate. Total liabilities include loans from financial and non-financial institutions, personal loans, and rent deposits received.[3] Table 1 summarizes the cross-sectional wealth statistics for the average household as well as the median, top 20th, and bottom 20th percentile of the household distribution for each type of assets and liabilities. We also report the cross-sectional mean and median ratios of housing value to net worth as well as the average ratio of rent deposit to total non-housing assets. All units are normalized by the average annual earnings between 1999 and 2005.[4]

From the summary statistics of wealth portfolio, some stylized features of the Korean households' wealth portfolio are listed as follows:

1. Housing is the most important asset in Korea with the average housing to total net worth ratio around 61%.
2. Housing is more unevenly distributed than net worth when measured by the percentile ratio $\frac{p80}{p50}$. This percentile ratios for housing and net worth are, respectively, 3.37 and 2.66. The uneven distribution of housing is also supported by a higher value of Gini coefficient. The average Gini index for housing is 0.679 whereas the corresponding Gini for net worth is 0.656.[5]
3. For non-housing assets, non-financial assets such as real estate properties take larger share than financial assets such as bank deposits. Within financial assets category, a large share is taken by rent deposits, which is a form of savings for renters, who tend to be young and poor. On average, rent deposits take approximately 25% of total non-housing assets in Korea.[6]

One issue is how well the household surveys of wealth match the aggregate measures. On top of misreporting problem, the KLIPS data does not over-sample the wealthy, and, thus, gross wealth estimated from the survey is likely to under-represent the aggregate wealth of the economy. Regarding the composition of wealth, since wealthier households tend to hold more in financial assets, the relative share of financial assets is expected to be higher in the aggregate economy than in the KLIPS data. Further study is needed to bridge the gap between the two different data sources.

3 KLIPS survey does not specifically ask any outstanding mortgage balance.

4 Note that row-wise, the figures add up in the ‘Average’ column, while the other rows do not as we look at the cross-sectional distribution of asset holdings for each type of assets and liabilities.

5 As a comparison, in the United States, financial asset is the major asset for average households and the housing asset is more equally distributed than the net worth as indicated by a lower value of Gini index. See Kennickell (2003).

6 Analogously, Cho (2005) estimates the aggregate chonsae deposit to be around 40% of GDP in Korea.

Table 2
Age-wealth profile.

	Average	Median	Top 20%	Bottom 20%
Net worth				
25–34	2.12	1.47	3.23	0.35
35–44	4.32	2.76	6.57	0.59
45–54	6.36	3.44	9.29	0.86
55–64	6.61	3.52	9.80	0.94
65–74	5.51	2.89	8.41	0.68
75–83	4.45	2.16	6.66	0.50
Housing				
25–34	0.86	0.00	1.37	–
35–44	2.61	0.77	4.60	–
45–54	4.06	2.58	6.37	–
55–64	4.15	2.69	6.32	–
65–74	3.55	2.03	5.76	–
75–83	3.15	1.53	5.29	–
Non-housing net worth				
25–34	1.26	0.84	2.25	−0.03
35–44	1.71	0.67	2.94	−0.45
45–54	2.30	0.50	3.30	−0.57
55–64	2.46	0.53	3.62	−0.41
65–74	1.97	0.28	2.76	−0.12
75–83	1.30	0.20	1.92	−0.28

2.2. Age-wealth profile

The profile of household wealth and the wealth portfolio composition strongly vary by age of the household head.[7] Typically, young households do not invest in risky assets. Most of them live in a rental housing and are saving to buy a house. This is more pronounced in Korea where young households are not eligible to mortgage loans and, thus, most have no option but to live in rental housing. Once they accumulate enough savings to buy a house, they then start investing in risky assets. Apart from primary housing, investment in risky assets predominantly goes into other non-financial assets, rather than financial assets, such as stocks or bonds. Older age families seem to sell their risky assets and shift their portfolios into safer assets. Some older age households may also move in with their children, which involves significant inter-vivos transfers.[8] Table 2 summarizes the age-wealth profile of different age cohorts and reports the average, the median, top 20th, and bottom 20th percentile. For comparison with the model shown in Section 3, I combine non-housing asset net of total liabilities and define it as 'non-housing net worth'.

The main features of wealth and portfolio choice over the lifecycle are summarized as follows:

1. The average profiles of net worth as well as housing and non-housing net worth all show a hump-shaped pattern over the lifecycle with peak occurring at the age cohort of 55–64.
2. Upon retirement, while average households decumulate assets with the average net worth for the 75–83 age cohort around 2/3 of the peak level, the rate of decumulation is higher for non-housing net worth than for housing assets. For the 75–83 age cohort, non-housing net worth and housing assets are approximately 53% and 76% of the their peak level, respectively.
3. As for the portfolio composition, non-housing net worth is the most important type of wealth for younger households aged 25–34, but its significance declines afterward, with housing becoming the primary source of wealth accumulation. Even after retirement, household wealth is mostly geared toward owner-occupied housing.
4. For median households within each age cohort, the profiles of net worth and housing show a hump-shaped pattern over the lifecycle, whereas the profile of non-housing net worth decreases monotonically by age. This is due to the fact that median households in the earlier stages of the lifecycle are predominantly renters and their non-housing net worth is largely comprised of rent deposits.

Table 3
Homeownership profile over the lifecycle.

Age cohort	Homeownership (%)
25–34	21.7
35–44	49.8
45–54	67.4
55–64	74.1
65–74	73.7
75–83	69.1
Total	58.1

2.3. Homeownership

Since owner-occupied housing is the most important part of household wealth in Korea, the decision to buy a house or to rent has significant implications for the wealth portfolio. Thus, it is important to take a closer look at how the distribution of homeownership varies by age. Table 3 shows the average homeownership ratio, or the fraction of households who are homeowners, between 1999 and 2005 for different age cohorts.

While the average homeownership ratio is around 58%,[9] the profiles of homeownership vary by age with a hump-shaped pattern over the lifecycle and slow decrease upon retirement. Majority of households aged between 25 and 44 are renters: approximately 80% for the 25–34 age cohorts and 50% for the 35–44 age cohorts. The low homeownership ratio in the early stages of the lifecycle is attributed to a lack of long-term mortgage loans and high down-payment requirement, both of which makes it longer for young households to purchase a house. The homeownership ratio increases with age and peaks at the age group of 55–64, after which it plateaus.

3. Benchmark model

A simple and parsimonious finite-horizon lifecycle model is set up to calibrate the wealth accumulation and portfolio choice of average Korean households, so that the model predictions match some key features of the data

[7] Household head in the KLIPS survey is defined as 'the representative person in the household' not as the oldest or the person with the highest income. The summary statistic shows that 84.1% of household heads are male with a median age of 47.

[8] Korean census survey in 1993 shows that 75% of agents aged 60 and above live with their offspring.

[9] Compared to other advanced countries such as the US or the UK, this ratio is almost 10 percentage points lower.

shown in the previous section. The model takes a partial equilibrium framework, as housing returns are exogenously given in the model. We specifically allow for the following features related to housing:

- housing tenure choice, where people can decide to rent as an alternative to buying a house,
- stochastic rates of return on the housing stock,
- and the ability to use housing as collateral.

3.1. Demographics

Each model period is calibrated to correspond to 2 years. Agents or households, which will be considered as an equivalent concept, actively enter into working life at 25 (denoted as $j = 1$ in the model) and live with some probability until 83 (denoted as $J = 30$), at which age she dies for certain. Agents work and receive earnings until the age of mandatory retirement denoted as j^*. Following each period after retirement, agents face a positive probability of dying. This is denoted by v_j, which is the exogenously given survival probability at age $j + 1$ conditional on being alive at age j. The unconditional survival probability for an agent aged $j + 1$ is thus given by $\prod_{s=1}^{j} v_s$. Since death is certain after age J, $v_J = 0$. Upon death, household's net worth is seized away by the government and equally redistributed to all working households as transfers T.[10] For simplicity, there is no population growth nor fertility choice.

3.2. Preferences

Agents derive utility from consumption of non-housing goods, c, and from the flow of services from housing stock, h, as well as from bequests, q, left upon death. Assuming agents derive utility from leaving a bequest, also known as a 'warm-glow' altruism, is a simple way to incorporate bequests into the model without introducing any complexities of intergenerational strategic interactions. The service flow from housing, $f(h)$, is proportional to the housing stock ($f(h) = h$). Following the set up by Platania and Schlagenhauf (2002) and Ortalo-Magné and Rady (2006), we assume that the utility derived from housing unit is higher for a homeowner than for a renter.[11] That is, renters (with indicator $I = 0$) will only derive a fraction $\lambda < 1$ of utility compared to a homeowner (with indicator $I = 1$) who has the same size of housing stock.

The utility function for a household aged j is of CRRA type as follows:

$$U(c_j, f(h_j), n_j) = n_j \frac{\left[\left(\frac{c_j}{n_j}\right)^{\omega}\left(\frac{f(h_j)}{n_j}\right)^{(1-\omega)}\right]^{1-\gamma}}{1-\gamma} = n_j^{\gamma}\frac{\left[c_j^{\omega} f(h_j)^{(1-\omega)}\right]^{1-\gamma}}{1-\gamma} \quad (1)$$

where $f(h_j) = I_j h_j + (1 - I_j)(\lambda h_j)$

$$I_j = \begin{cases} 1, & \text{if homeowner} \\ 0, & \text{otherwise} \end{cases}$$

Here, n_j is the exogenously given average effective family size adjusted by the adult equivalence scale, as measured by Fernandez-Villaverde and Krueger (2001), and captures the economies of scale in household consumption pointed out by Lazear and Michael (1980). The parameter ω measures the share of non-housing consumption to housing expenditures, and γ is the relative risk aversion parameter.

As for the utility derived from leaving bequests q, we follow De Nardi (2004) specified as follows:

$$\varphi(q) = \varphi_1\left[1 + \frac{q}{\varphi_2}\right]^{1-\gamma} \quad (2)$$

The term φ_1 reflects the parent's concern about leaving bequests to children, while φ_2 measures the extent to which bequests are luxury goods.

Finally, the lifetime utility function can then be written as[12]:

$$E\left\{\sum_{j=1}^{J}\beta^{j-1}\left(\prod_{s=1}^{j} v_{s-1}\right)\left[U(c_j, f(h_j), n_j) + (1 - v_j)\varphi(q_j)\right]\right\} \quad (3)$$

3.3. Income process

Working households receive labor earnings denoted as y, which is the age-dependent deterministic earnings path, subject to a stochastic component η. The idiosyncratic shock $\log\eta$ follows a first-order autoregressive process (AR(1)) as follows:

$$\begin{aligned} &\log\eta' = \rho\log\eta + \epsilon \\ &\epsilon \sim \mathcal{N}(0, \sigma^2) \end{aligned} \quad (4)$$

The stochastic process is assumed to be identical across households and follows a finite-state Markov process, which is characterized by the transition function $\Pi(\eta'|\eta)$ where $\eta \in E = \{\eta_1, \ldots, \eta_N\}$. The deterministic income path is calibrated to reflect the average lifetime labor earnings profile from the KLIPS data.

3.4. Asset portfolio and housing choice

All agents enter into their working life with zero financial assets and some transfers received from the government as a part of intergenerational transfers. Initially, an exogenous fraction o of the agents enter as homeowners and the remaining $1 - o$ as renters. Every period, a household decides to become a renter or a homeowner by choosing the stock of housing for next period. We assume that housing is not perfectly divisible. For this, we define a minimum size $\underline{H}$ for owner-occupied housing stock as was introduced in Cocco (2005). Fraction o of agents entering as homeowners in the beginning of their lifecycle are all assumed to live in the minimum-sized housing.

[10] One way to interpret this redistribution is to consider it as the sum of inter-vivos transfers and bequests.

[11] Glaeser and Shapiro (2002) discuss the positive externalities of homeownership over renting in detail. Poterba (1992) cites various tax benefits such as home mortgage interest deductions and tax deductions on the capital gains from selling the house.

[12] Here, $v_0 = 1$.

Housing stock can also be used as collateral for homeowners such that they can borrow up to a fraction, κ, of the next period housing value. As such, κ is the loan-to-value (LTV) ratio, and $1-\kappa$ is the down-payment ratio. The collateral constraint is as follows:

$$a' \geqslant -\kappa h' \tag{5}$$

where a' is the financial net worth next period. For a household without a house, the borrowing constraint reduces to the non-negativity constraint form $a' \geqslant 0$.

For those unable to afford a minimum housing size will acquire housing service by renting. A renter has an option to continue renting or to buy a house and become a homeowner. If the renter decides to rent in the next period, a rental deposit $\theta h'$ is paid in advance, which is a fraction θ of the housing stock. On the other hand, if the renter wants to become a homeowner, she can purchase a house at h'.

A homeowner, on the other hand, can decide whether to keep the house or to sell and move. If a homeowner is selling the house, she faces the same choice as the renter; that is, the homeowner can either choose to rent or buy another house. Due to the illiquid nature of the housing investment, selling the house incurs a transaction (or liquidation) cost (ϕ) proportional to the value of the house. In addition, owning a house serves a dual purpose of not only providing housing service flow, but also as an equity subject to risky returns if the homeowner decides to sell the property. The realization of the housing shock, ξ is discretized and follows an iid normal process with mean r_h and variance σ_h^2. Net of transaction cost and housing shock, homeowner receives $(1-\phi)h(1+\xi)$ upon selling the housing.

3.5. Government and taxation

In this economy, the government implements a self-financed pay-as-you-go social security system. The social security system involves taxation on the labor earnings at the flat tax rate τ and redistribution of the revenue to the retired households. The constant social security benefit b is proportional to the average lifetime income at the replacement rate χ. In addition, the government fully taxes away the bequests q left by the deceased, which is equally redistributed to working households as transfers T.

3.6. Household recursive problem

This subsection describes the recursive decision problems faced by the households in Korea. The state space is a set $X = \{j, a, h, I, \eta, \xi\}$, where j is the household age, a and h refer to the financial net worth and the stock of housing carried from the previous period, respectively, I is the tenure status, and η and ξ are the stochastic shocks to labor earnings and housing. Given the tenure status, a renter decides to remain as a renter or to become a homeowner. On the other hand, a homeowner decides first whether to keep the house or to sell and move, after which the homeowner faces the same option as the renter. Incorporating this tenure decision, the value function for a household is the maximum of three different values, which depend on the tenure choice made in the next period: $V(X) = \max\left\{V^C(X), V^K(X), V^R(X)\right\}$. The functions V^C, V^K, and V^R are, respectively, the value functions of changing the size of the house, maintaining the current house, and renting next period. Note that renters can only choose to rent (V^R) or buy a house (V^C).

At the beginning of every period, working households receive labor earnings subject to an earnings shock and net of social security payroll taxes, $(1-\tau)y\eta$. Retired household, on the other hand, receives pension benefits b, which is a constant fraction χ of the average household earnings. I use the indicator I^w to distinguish working ($I^w = 1$) vs. retired ($I^w = 0$) households.

3.6.1. Value function of changing the house next period: V^C

At the beginning of each period, households carry financial net worth with realized risk-free returns, $(1+r)a$. For housing, a homeowner has a position on the housing capital net of transaction costs and housing shock upon selling the existing owner-occupied housing. In net terms, the homeowner receives $(1-\phi)h(1+\xi)$. On the other hand, a renter receives the rent deposit paid in the last period without any interest, denoted as θh. Given the earnings and the assets held, the household then chooses the consumption of non-housing goods c, next period financial net worth a', and buys a new housing stock h'. In the case of retired households who do not survive until the next period, all of their assets are left as a bequest ($q = a' + h'$), which is redistributed equally to working households as transfers, T. As the household chooses to stay as a homeowner, the minimum housing size constraint holds, and the household can borrow up to a certain fraction of the value of the house as collateral. The recursive problem for homeowners changing the house or renters buying a house is shown as follows:

$$V^C(j,a,h,I,\eta,\xi) = \max_{c,a',h'} \left[U(c,h,n) + \nu\beta E(V(j+1,a',h',I',\eta',\xi')) + (1-\nu)\varphi(q)\right] \tag{6}$$

subject to

$$c + a' + h' \leqslant I^w((1-\tau)y\eta + T) + (1-I^w)b + (1+r)a + I(1-\phi)h(1+\xi) + (1-I)\theta h$$
$$a' \geqslant -\kappa h'$$
$$c \geqslant 0$$
$$h' \geqslant \underline{H}$$
$$q = a' + h'$$

3.6.2. Value function of homeowners keeping the house: V^K

Since the homeowner maintains the current house, the homeowner receives h and chooses housing stock in the next period equal to the current period housing stock, $h' = h$. Given the earnings and the assets held, the household then chooses the consumption of non-housing goods c, next period financial net worth a', and maintains the current housing stock, $h' = h$. The problem for homeowners keeping the house is formed recursively as follows:

$$V^K(j,a,h,I,\eta,\xi)=\max_{c,a',h'}[U(c,h,n)+v\beta E(V(j+1,a',h',I',\eta',\xi'))+(1-v)\varphi(q)] \quad (7)$$

subject to

$$c+a'+h'\leqslant I^w((1-\tau)y\eta+T)+(1-I^w)b+(1+r)a+h$$
$$a'\geqslant -\kappa h'$$
$$h'=h$$
$$c\geqslant 0$$
$$q=a'+h'$$

3.6.3. Value function of renting next period: V^R

For housing, a homeowner has a position on the housing capital net of transaction costs and housing shock upon selling the house. In net terms, the homeowner's housing capital is $(1-\phi)h(1+\xi)$. On the other hand, a renter simply receives the rent deposit paid in the last period, θh. Given the earnings and the assets held, the household then pays rental deposit $\theta h'$ in advance. In case the retired households do not survive until the next period, all assets are left as bequest ($q=a'+\theta h'$), which now includes the rental deposit. As the household chooses to become a renter, the minimum housing size constraint no longer holds, and the household cannot make collateralized loans. The problem for households renting next period can be formed recursively as follows:

$$V^R(j,a,h,I,\eta,\xi)=\max_{c,a',h'}[U(c,h,n)+v\beta E(V(j+1,a',h',I',\eta',\xi'))+(1-v)\varphi(q)] \quad (8)$$

subject to

$$c+a'+\theta h'\leqslant I^w((1-\tau)y\eta+T)+(1-I^w)b+(1+r)a+I(1-\phi)h(1+\xi)+(1-I)\theta h$$
$$c,a',h'\geqslant 0$$
$$q=a'+\theta h'$$

3.7. Model analysis – first-order conditions

In this subsection, we analyze the first-order conditions derived from the household optimization problem.

3.7.1. Changing the house next period

Consider the case of changing housing arrangements next period (corresponding to the value function V^C). The first-order conditions with respect to c, a', and h' yield:

$$\beta^{j-1}U_1(c,h)-\lambda=0 \quad (9)$$
$$\beta^{j-1}(1-v)\varphi_1(a',h')-\lambda+(1+r)E\lambda'=0 \quad (10)$$
$$\beta^{j-1}(1-v)\varphi_2(a',h')+(1-v')EU_2(c',h')-\lambda+(1-\phi)E(1+\xi')\lambda'=0 \quad (11)$$

where λ and λ' denote the multipliers on the budget constraint in the Lagrangian, U_i and φ_i denote marginal utilities of consumption and bequest with respect to the ith argument. We also assume that in the next period, the homeowner decides to sell the property again, which is subject to transaction costs and shocks to housing investment, as shown in the last term in the Eq. (11). Re-arranging the first-order conditions shown above, we get:

$$(1-v')EU_2(c',h')=E[(1+r)-(1-\phi)(1+\xi')]U_1(c',h') \quad (12)$$

Note that in the specific case of no uncertainty, $1+\xi=1+r_h$, and no mortality ($v'=0$), the above equation can be written as

$$\frac{U_2(c',h')}{U_1(c',h')}=(1+r)-(1-\phi)(1+r_h) \quad (13)$$

which is reduced to the standard user cost formula for housing which equates the marginal rate of substitution between housing and non-housing to the rental rate per unit of housing service which can be approximated as $r+\phi-r_h$.

3.7.2. Becoming a renter next period

Now consider the case of renting next period (corresponding to the value function V^R). The first-order conditions with respect to c and a' yield Eqs. (9) and (10), while the first-order condition with respect to h' yields:

$$(1-v)\varphi_2(a',h')\theta+(1-v')EU_2(c',h')-\theta\lambda+\theta E\lambda'=0 \quad (14)$$

Re-arranging the first-order conditions, we get:

$$(1-v')EU_2(c',h')=\theta rEU_1(c',h') \quad (15)$$

Note that in the absence of uncertainty and mortality risk, the above equation can be written as

$$\frac{U_2(c',h')}{U_1(c',h')}=\theta r \quad (16)$$

4. Calibration

The set of parameters are divided into those that can be estimated independently of the model or are based on the estimates provided by other literature and data, and those that are chosen such that the predictions generated by the model can match a given set of targets. All parameters are adjusted to the 2 year span that each period in the model represents. For the first group of calibrated parameters, Table 4 lists the parameters provided by other literature and data. For some parameter values not directly estimated from the Korean data, we conduct a sensitivity analysis in Section 6 to test the robustness of our parameter choices.

Regarding the preference parameters, the relative risk aversion coefficient, γ, is taken from Attanasio et al. (1999), which falls in the range commonly used in the macroeconomics literature (1–3). The coefficient ω measures the weight of non-housing consumption to housing in the household expenditure. Due to the lumpy nature of chonsae payment, period-by-period housing expenditure in the KLIPS data is not directly observable. We thus take the value of ω from Ogaki and Reinhart (1998). For λ, which measures the degree of households' preference for homeownership over renting, we choose a value of

Table 4
Parameter definition and values.

Preference		
γ	Risk-aversion coefficient	1.5
ω	Share of non-housing expenditure	0.85
λ	Utility premium	0.7
Income process and interest rate		
y_j	Earnings profile	Appendix
ρ	Persistence of earning process	0.94
σ_y^2	Innovation of earning process	0.35
r	Risk-free interest rate	4.1%
Housing		
θ	Rent–deposit ratio	0.6
ϕ	Liquidation cost	0.07
κ	Loan-to-value ratio	0.2
$\bar{\xi}$	Average housing return	4%
Demographics		
j^*	Retirement age	19 (age 61)
χ	Replacement ratio	40%
v_j	Survival probability	Appendix
n_j	Family size	Appendix
o	Homeownership ratio for 25-year-old	13%
τ	Payroll tax rate	14.0%

0.7, which was used in Platania and Schlagenhauf (2002). Given there are no empirical estimates for this value, we later conduct sensitivity analysis on the relationship between the homeownership preference parameter and the aggregate homeownership.

The labor earnings for households follow a deterministic age-dependent trend as well as idiosyncratic shocks. The age-dependent deterministic earnings profile, y, was calculated from the estimate of the average earnings profile from the KLIPS data over the survey periods 1999–2005. As for the parameters governing the idiosyncratic shocks to earnings, since we do not have a lifecycle estimate of the earnings process, we take the ρ_y from De Nardi (2004) and adjust to the fact that our model period represents 2 years. On the other hand, we choose the variance parameter σ^2 to match the Gini coefficient for earnings in the age groups between 25 and 60 from the KLIPS data. The annual risk-free interest rate, r, was set at 4.1%, which was the average annual real interest rate from 1986 to 2002. The earning shocks are discretized into a four-state Markov chain with values given by {0.4288,0.7541, 1.3261,2.3321}, and the transition matrix Q_y is given as follows:

$$\begin{bmatrix} 0.5904 & 0.1954 & 0.1266 & 0.0877 \\ 0.3823 & 0.2218 & 0.1919 & 0.2040 \\ 0.2040 & 0.1919 & 0.2218 & 0.3823 \\ 0.0877 & 0.1266 & 0.1954 & 0.5904 \end{bmatrix}$$

For housing parameters, the rent–deposit ratio, θ, was taken to be 0.6 which falls in the middle of 0.4 and 0.8, taken from Cho (2005). For the liquidation cost parameter, ϕ, while there is no direct estimate of the relocation cost of tax and agency cost, we assume the transaction cost to be 7% of the property value, which is taken from Gruber and Martin (2003). We take the average loan-to-value ratio, κ, to be 20%, which implies the average down-payment requirement to be 80%. For housing returns, we assume that the housing returns are subject to a two-state iid shock taking values {0%,8%} with equal probability. The average housing return of 4% is taken from the Monthly House Prices index data provided by Kookmin Bank during the period 1986–2002.

Table 5
Parameters to match target ratios.

Parameters	Definition	Value
β	Discount factor	0.95
$\underline{H}$	Minimum housing size	1.88
φ_1	Bequest parameter	−23.0
φ_2	Bequest parameter	8.0

For demographics, the retirement period in the model is 19, which corresponds to the age of 61, after which the household receives constant social security benefit with a replacement ratio of 40% ($\chi = 0.4$). The conditional survival probabilities for the working households were assumed to be 1, while those for the retired households were taken from the Korea Life Table supplied by the National Statistical Office of Korea. The KLIPS data was used to calibrate the average household size and we use the adult equivalent scale measured in Fernandez-Villaverde and Krueger (2001) to find the average effective family size, n_j. We take exogenously the fraction of homeowners for the households entering into the lifecycle from the KLIPS data. The age profiles of the survival probabilities, effective family size, as well as the exogenous earnings profile are detailed in the Appendix. Finally, the payroll tax rate on earnings, τ, was endogenously chosen to balance the government budget, where tax revenues are used to finance social security benefits.

The next four parameters are jointly chosen such that the predictions generated by the model can match a given set of aggregate ratios as shown in Table 5.

First, we calibrate the discount factor, β, to match the average net worth to earnings, which is 5.12 from the KLIPS data between 1999 and 2005. The minimum housing value, $\underline{H}$, is calibrated to match the average homeownership ratio, which is 58% in the data. The implied value for the minimum housing value is 1.88 times the average earnings. The bequest parameter, φ_1, is chosen to match the bequest to wealth ratio in the data. The amount of bequests left by each age group are estimated using the survival probabilities and the wealth data, following the method proposed by Shimono and Ishikawa (2002). Aggregating the amount of bequests over all ages, the annual flow of bequest to wealth ratio is found to be 0.7%.[13] As for φ_2, we match the fraction of households who receive bequests in a given year, which is around 1.8% from the 2006 wave of Korea Longitudinal Study of Ageing.

[13] Gale and Scholz (1994) estimate the annual flow of bequest to be 0.88% of the aggregate net worth using the 1983 wave of the Survey of Consumer Finances. Our estimate is consistent with studies by Horioka et al. (2000) showing that the bequest motives in East Asian countries are weaker than in the United States.

Table 6
Aggregate statistics for benchmark simulation.

	Benchmark	Data
Wealth-to-earnings ratio	5.12	5.12
Homeownership ratio	58.2%	58.1%
Bequest-to-wealth ratio	0.6%	0.7%
Fraction of HH receiving bequests	1.9%	1.8%
Housing to wealth ratio	61.7%	61.0%

5. Results

5.1. Benchmark result

In this section, the results from the benchmark simulation are presented and the fit of the model is evaluated. The aggregate statistics of the benchmark simulation as well as the empirical counterparts from the Korean data are presented in Table 6. Using the parameter values chosen in Table 5, we match the aggregate statistics of the data well. Our model also generates housing to wealth ratio very close to its data counterpart, adding support to the aggregate fit of the model.

In Table 7, we construct the lifecycle profiles of net worth, wealth portfolio (housing vs. financial assets) and homeownership from the model simulation. The net worth is defined as the sum of the financial net worth and housing assets, $a + h$. Assuming a 'warm-glow' bequest motive allows the model to generate sufficient wealth during retirement periods to match the data. Our model also captures the profile of housing assets observed in the data, with rapid accumulation of housing occurring early in life. This is attributed to the role of housing as collateral. The age profile of homeownership thus follows a hump-shaped pattern.

Comparing the age profiles of the model simulation with the data shown in Table 2, note that the model uses parameters that capture the economy in the aggregate, and that the information from the age profile in the data was used minimally.[14] In addition, we abstract from changes in the population demographics[15] and economic growth. Given the abstraction of the model presented, the profiles of net worth, housing, as well as homeownership ratio show hump-shaped pattern with their peak taking place among the age group of 55–64, which matches the data well as shown in Table 2. On the other hand, the curvature of the hump reproduced from the benchmark simulation is larger than what the data shows, which partly implies that the model does not reproduce enough motive for retired households to maintain their level of wealth. For the 75–83 age group, the average net worth and the housing wealth is around 32% and 22% of their peak level, respectively. Our benchmark model's partial ability to account for the curvature of the age profile comes from our assumption of simple bequest motive and constant retirement benefit plan as well as not taking into account other types of precautionary savings motive. As for portfolio composition over the lifecycle, non-housing net worth has 58% share in total net worth for younger households aged 25–34, which matches the data. Housing becomes the dominant source of wealth accumulation for households aged between 35 and 74. For the cohorts aged 75–83, most households switch back to renting with a larger share of net worth held in the non-housing assets.

Table 7
Age profile of wealth and homeownership profile.

	Average	Median
Net worth		
25–34	2.20	1.55
35–44	5.60	3.94
45–54	7.92	5.75
55–64	9.73	7.27
65–74	6.33	4.65
75–83	3.13	1.88
Housing		
25–34	0.93	0.00
35–44	3.33	3.26
45–54	4.64	3.97
55–64	4.93	4.24
65–74	3.36	3.09
75–83	1.04	0.00
	Average (%)	
Homeownership		
25–34	21.2	
35–44	61.5	
45–54	77.5	
55–64	83.2	
65–74	71.6	
75–83	25.4	

5.2. Policy experiments

In this section, the quantitative roles played by the institutional features of the mortgage and the rental market are analyzed and compared to the benchmark case. First, to highlight the role of mortgage system, the Korean government recently introduced a full-fledged mortgage loan program similar to that in the United States. While it is early to assess the impact of this recent policy introduction, modifying the model by incorporating mortgage loans may shed light on how households' tenure decision will be affected, as well as the overall portfolio composition of wealth over the lifecycle. One way to incorporate mortgage into the model is to introduce an asset from which people can borrow against. However, given the existing number of state variables, adding another state variable would only complicate further the computation without providing many beneficial implications. Thus, instead of adding another state variable, we explore two different LTV ratios: 50% to represent a 'partial' mortgage expansion and 80% to reflect the average LTV ratio in the United States. This implies that households can now finance housing purchase with an upfront down-payment of 50% and 20% of the value of the house. It is also assumed that households with a mortgage can refinance and adjust their mortgage balance without any adjustment cost.

Next, to document the significance of the unique rental system in Korea, we modify the chonsae system to mimic

[14] One information taken from the cross-sectional age profile data is the homeownership ratio of the initial age groups of 25–26.

[15] For example, in the model, there are equal number of households aged between 25 and 60, whereas the distribution in the cross-sectional data shows a big concentration of households in the age cohort of 35–44.

Table 8
Aggregate statistics under policy experiments.

	Benchmark	LTV 50%	LTV 80%	Alt. rental
Wealth-to-earnings ratio (average)	5.116	5.057	5.038	4.940
Homeownership ratio	58.2%	60.8%	64.1%	50.4%
Welfare (% change)		0.01%	0.09%	−1.85%

the rental system in the United States, where renters pay periodic rental payment. The annual rental cost is now assumed to be a fraction μ of the house value and corresponds to the interest income landlords would receive had they placed the chonsae deposit into a deposit institution. We thus set $\mu = r\theta$. The detailed set up of the alternative rental market arrangement is shown in the Appendix. For our counter-factual policy experiments, all other calibrated parameters remain unchanged from the benchmark simulation.

Table 8 highlights the aggregate statistics wealth and homeownership under our policy experiments. We also report changes in the average discounted lifetime utility, which represents aggregate welfare gain or losses. The age profiles of wealth and homeownership are shown in Table 9.

Relaxing the collateral constraint enables households to become homeowners earlier in life than under the benchmark case as housing financing comes at a lower downpayment requirement. As a result, the overall homeownership increases in the aggregate. Quantitatively, the aggregate homeownership ratio rises by 2.6 and 5.9 percentage points under the LTV ratio of 50% and 80%, respectively. On average, this implies that a 10 percentage points increase in the LTV ratio is able to account for 1 percentage point increase in the homeownership ratio. Across cross-sectional age demographics, homeownership peaks at the age cohort of 45–54 when the LTV ratio rises to 80%, implying that a larger value of LTV ratio changes the overall curvature of the hump-shaped profile of homeownership over the lifecycle. The magnitude of this change in the homeownership is larger the younger and the older the age cohort. With a 80% LTV ratio, the homeownership for the cohorts aged 25–34 and 75–83 increase by 6.6 and 14.8 percentage points, respectively. In addition to higher propensity to purchase an owner-occupied housing, the share of wealth held in housing increases. For the cohorts aged 25–34, the average housing wealth rises by a margin of 15–34%, implying that a 10 percentage points increase in the LTV ratio is associated with approximately a 5% increase in the housing asset accumulation for the young age cohort. Housing wealth increases significantly for the cohort aged 75 and above as well, with a 10 percentage points increase in the LTV ratio associated with a 10% increase in the housing asset. Despite a larger fraction of wealth held in housing, the aggregate net worth declines slightly when we increase the LTV ratio. The wealth-to-earnings ratio is reduced by 1.2% and 1.5% when the LTV ratio rises by 30 and 60 percentage points, respectively. The lower wealth-to-earnings ratio is partly attributed to the fact that the household portfolio shifts toward housing which on average yields a lower rate of return than financial assets. Despite lower wealth accumulation in the economy, the average welfare gain is slightly positive for both policy experiments. Welfare gains are partly attributable to the fact that relaxing the collateral constraint enables households to better smooth their aggregate consumption over the lifecycle.

Table 9
Age profile under policy experiments.

	Benchmark	LTV 50%	LTV 80%	Alt. rental
Net worth				
25–34	2.20	2.14	2.13	1.38
35–44	5.60	5.45	5.34	4.42
45–54	7.92	7.75	7.63	6.85
55–64	9.73	9.56	9.46	8.81
65–74	6.33	6.17	5.98	5.36
75–83	3.13	2.95	2.67	1.81
Housing				
25–34	0.93	1.07	1.25	0.76
35–44	3.33	3.56	3.97	2.81
45–54	4.64	4.79	4.95	4.13
55–64	4.93	4.98	4.94	4.62
65–74	3.36	3.42	3.53	2.64
75–83	1.04	1.28	1.66	0.57
Homeownership				
25–34	21.2%	24.3%	27.8%	18.3%
35–44	61.5%	65.9%	73.1%	54.3%
45–54	77.5%	80.2%	82.7%	70.9%
55–64	83.2%	83.7%	82.1%	79.0%
65–74	71.6%	72.4%	74.7%	54.0%
75–83	25.4%	30.7%	40.2%	13.5%

When the rental arrangement is altered to a periodic rental payment instead of a lump-sum deposit, we let the annual rental rate to be $\mu = r\theta$ fraction of the housing value. Since we do not change our calibrated parameter values, the annual cost of rental housing is now approximately 2.4% of the house value.[16] Keeping all other parameter values fixed, a switch in the rental arrangement lowers the aggregate homeownership ratio by 7.8 percentage points and the aggregate wealth-to-earnings ratio by 3.4%. As for the age profile, both net worth and housing, as well as the homeownership ratios are lower for all age cohorts. The peak of homeownership ratio at the age group of 55–64 is 4.1 percentage points lower than the benchmark, and after retirement households switch back to renting more quickly as the homeownership ratio declines by 25 percentage points for the age group of 65–74, compared to 11.6 percentage points decline under the benchmark scenario. Compared to the benchmark result, the biggest decline in the homeownership occurs for the retired households, with declines of 17.6 and 11.9 percentage points for the 65–74 and the 75–83 age groups.

6. Sensitivity analysis

In this section, we check the robustness of the main findings in the benchmark economy to the choice of key parameters and discuss the cost and benefit of owning vs. renting. We specifically focus on the rent–deposit ratio

[16] This value is also known as the gross rental yields, or the annual rental income as a percentage of property purchase price.

Table 10
Aggregate statistics (sensitivity analysis).

	θ		λ		ϕ		μ
	0.5	0.7	0.6	0.8	0.06	0.08	0.04
Wealth-to-earnings ratio	5.08	5.16	5.21	4.90	5.22	5.09	5.40
Homeownership ratio	53.2%	60.2%	60.8%	49.5%	59.4%	56.6%	62.4%

parameter (θ), utility premium parameter for homeownership (λ), and transaction cost parameter (ϕ). Note that ϕ enters into Eq. (1) and θ enters into Eq. (2), while the left hand side of both equations would be different under the presence of $\lambda < 1$. We also investigate the implications of applying a higher annual rental cost μ in the policy experiment section. Other calibrated parameters are kept fixed to the benchmark experiment. Table 10 highlights the aggregate statistics wealth and homeownership under our policy experiments, while the age profiles of wealth and homeownership are shown in Table 11.

For the rent–reposit ratio, a lower value of θ implies that renting becomes relatively cheaper than buying a house, which results in a lower aggregate homeownership ratio. Our analysis shows that 0.1 reduction in the rent–deposit ratio is associated with a 5 percentage points reduction in the overall homeownership ratio as well as a lower housing equity and wealth-to-earning ratio. On the other hand, at a higher value of θ (70%), rental housing becomes relatively more expensive, thus making it more attractive for the households to purchase housing earlier in the lifecycle and remain homeowners. The profile of housing and homeownership reflect this change in the relative rental price. For the utility premium parameter, λ, a lower value of λ implies higher benefit for homeowners and increases the overall homeownership ratio. A decrease in the value of λ from 0.7 to 0.6 increases the homeownership ratio by 2.6 percentage points as well as increasing the wealth-to-earnings ratio by 1.8%. Finally, for the transaction cost parameter, ϕ, lower transaction cost implies less sunk cost in housing transaction which promotes both wealth accumulation and homeownership. A 1 percentage point reduction in the transaction cost increases the wealth-to-earnings ratio by 2.0% and the homeownership ratio by 1.2 percentage points. Lower transaction cost is also associated with higher housing wealth accumulation. In summary, the benefit of owning would be higher under lower values utility premium parameter and the transaction cost parameter and a higher value of rent–deposit ratio. This is also reflected on the higher aggregate homeownership ratio. As for introducing a higher annual rental cost of 4% of house value, we note that higher rental cost increases the relative benefit of owning vs. renting and increases both the wealth accumulation and the homeownership ratio in the economy. Quantitatively, the wealth-to-earnings ratio increases by 5.6% while the homeownership ratio increases by 4.2 percentage points. In terms of welfare, higher wealth accumulation joint with higher homeownership ratio promotes social welfare as the average lifetime discounted utility increases by 0.68%.

Table 11
Age profile (sensitivity analysis).

	θ		λ		ϕ		μ
	0.5	0.7	0.6	0.8	0.06	0.08	0.04
Housing							
25–34	0.82	1.00	0.99	0.77	1.01	0.86	0.92
35–44	3.15	3.44	3.41	3.00	3.53	3.12	3.18
45–54	4.52	4.71	4.70	4.31	5.01	4.33	4.57
55–64	4.69	5.08	5.08	4.46	5.61	4.52	5.07
65–74	2.92	3.47	3.50	2.81	3.60	3.31	3.55
75–83	0.89	1.07	1.21	0.73	1.11	1.01	1.15
Homeownership							
25–34	18.5%	22.5%	22.5%	17.1%	22.5%	19.9%	22.1%
35–44	57.9%	63.9%	63.5%	53.5%	62.4%	60.4%	62.7%
45–54	74.5%	79.0%	79.5%	69.2%	78.2%	77.0 %	80.9%
55–64	76.8%	86.1%	87.2%	72.0%	85.0%	81.1 %	89.9%
65–74	60.3%	74.0%	74.6%	58.0%	72.2%	69.1 %	76.9%
75–83	21.7%	26.3%	29.7%	17.6%	27.5%	22.4%	28.9%

7. Conclusion

We develop a quantitative theory of lifecycle wealth accumulation and asset portfolios to investigate the role of some unique institutional features of the Korean housing market. The chonsae system, the unique rental arrangement, and the lack of mortgage system in Korea do play significant roles in accounting for the observed features of wealth accumulation and portfolio composition in Korea. Also, various implications of counter-factual policy changes are analyzed, such as expanding the current mortgage loan system and introducing periodic rental payment in lieu of chonsae rental. An expansion of the mortgage system is expected to increase the average homeownership ratio, especially for younger households aged between 25 and 44 as well as older retired households aged 75 and above. Expanding the mortgage system also shifts households' portfolio toward housing assets which lowers the overall wealth accumulation in the economy as housing provides a lower return on average than financial assets. Introducing a periodic rental payment with gross rental yield of 2.4% of has the opposite effect of lowering homeownership ratio with the largest fall in homeownership taking place within the age group of 65–74.

It is important to note that the model abstracts from several issues. Data shows significant heterogeneity in households' wealth portfolios in terms of age and income. For example, the richest households have a disproportionately large share of the total wealth. However, the model presented in this paper does not sufficiently allow for this difference since it concentrates on the average household with limited source of household heterogeneity. Incorporating models of wealth inequality may help shed light on these issues and improve the model.

Second, our model abstracts from different housing taxation issues. Housing investment was widely considered as a safe means of wealth creation during periods of house price appreciation in Korea. Due to concerns on speculation, the government imposed various types transaction tax, property tax, as well as tax on non-owner-occupied housing. Our model also abstracts from the complexities of housing price fluctuations, which could impacts the size of debt leverage as well as the distribution of wealth. Particularly, over the past decade, house price appreciation has outpaced inflation and resulted in large wealth gains for some fortunate homeowners in Korea. More recently, with the extended fall in national house prices many of these gains have been reversed. Other issues not dealt in the model include changes in demographics and life expectancy, cohabitation issues, as well as economic growth. Incorporating these non-trivial issues are left for future extensions.

Appendix A. Alternative rental arrangement

To capture periodic rental payment system, renters now pay a fraction μ of the market value of the house, as well as a security deposit, which is equivalent to a 1 month rental payment (denoted as a fraction $\imath$ of the housing value). For the value function V^R, a renter at the beginning of the period receives security deposit, a fraction $\imath$ of the house value,[17] from the landlord with risk-free interest r. If the household is a homeowner, then the homeowner receives the value of housing with returns net of liquidation cost and housing returns. Given the earnings and assets held, the household then chooses the consumption of non-housing goods, c, next period financial net worth, a', and makes rental payment sh' and security deposit $\imath h'$ in advance. The problem for households renting next period can be formed recursively as follows:

$$\widetilde{V}^R(j,a,h,I,\eta,\xi) = \max_{c,a',h'}[U(c,h,n) + \nu\beta E(V(j+1,a',h',I',\eta',\xi')) + (1-\nu)\varphi(q)] \quad (17)$$

subject to

$$c + a' + (\mu+\imath)h' \leqslant I^w((1-\tau)y\eta + T) + (1-I^w)b + (1+r)a + I(1-\phi)h(1+\xi) + (1-I)(1+r)\imath h$$

$$c, a', h' \geqslant 0$$

$$q = a' + \imath h'$$

Appendix B. Computation of the model

Since there is no closed form solution to the model, the model is solved numerically to work out optimal decision rules as a function of the state variables: age (j), housing (h), non-housing net worth (a), tenure status (I), earnings shock (η), and housing return shock (ξ). The optimal decision rules were found by backward induction, starting from the terminal period J and working all the way recursively to the initial period. In period J, the value functions coincide with the sum of the period utility function and the bequest function, and, given the realization of the state variables, the consumption and bequest choices are trivial. Based on the period J policy functions, in every period prior to J, the values associated with the different choices of housing in the next period were calculated, and consumption and asset portfolio choices conditional on different housing choices were obtained subsequently. For choices of control variables that violate various constraints, a large negative utility is given so that an optimizing household would never opt for these choices. The realization of the earnings process is approximated using a Markov process following Tauchen and Hussey (1991). The state space for housing and financial assets were discretized into a finite number of grid points.

$$a \in \{a_{min}, \dots, 0, \dots, a_{max}\}$$
$$h \in \{0, \dots, \underline{H}, \dots, h_{max}\}$$

Whenever the upper or lower limits for the grids turned out to be binding in the solution to the problem, the upper and lower bounds were increased and the problem was solved again. In the end, the boundaries for the grids became sufficiently large and no longer imposed any constraint on the optimization process. Having solved the model using the grid search method, a large sample of different cohorts were simulated, and their optimal decisions over the lifecycle were recorded. Solving for the equilibrium, I take the following steps:

1. Guess the initial level of transfers T and payroll tax rate τ for working households.
2. Solve for the individual household's recursive problem from the terminal period J.
3. Given the policy function in period J, iterate backwards until the first period in life. For each period prior to period J, start with an initial guess for the policy function of non-housing net worth (a'_0) and solve for the individual household's recursive problem to find the policy function for consumption (c) and housing choice (h'). Find the policy function for non-housing net worth next period that satisfies the Euler equation (a'_1) and update the guess on the choice of the non-housing net worth and re-solve the household's recursive problem until convergence is reached for the policy function of non-housing net worth (a'_i). This yields the policy functions and the value functions for all periods.
4. Using forward induction of the policy function, compute the optimal decisions of the households over the lifecycle and compute the tax rate required to provide constant pension benefit for the retired households as well as the level of transfers to working households funded by the bequest left. Iterate until the tax rates and the transfers converge.

Appendix C. Calibrated parameters

Table 12.

[17] The notion of security deposit is used to keep track of housing as a state variable. In addition, when the agent dies next period, the deposit will become part of bequest as the agent did not move into the house in the following period.

Table 12
Earnings profile (y), survival probabilities (v), and family size (n).

Age	y	v	n
25	0.651	1.000	1.399
27	0.740	1.000	1.387
29	0.886	1.000	1.516
31	0.930	1.000	1.639
33	0.972	1.000	1.790
35	1.082	1.000	1.863
37	1.034	1.000	1.910
39	1.033	1.000	1.949
41	1.037	1.000	1.962
43	1.029	1.000	1.957
45	1.095	1.000	1.971
47	1.087	1.000	1.970
49	1.098	1.000	2.002
51	1.037	1.000	1.968
53	1.072	1.000	1.969
55	1.028	1.000	1.920
57	0.877	1.000	1.827
59	0.781	1.000	1.772
61	0.000	0.981	1.727
63	0.000	0.978	1.673
65	0.000	0.973	1.611
67	0.000	0.968	1.531
69	0.000	0.961	1.492
71	0.000	0.952	1.528
73	0.000	0.941	1.423
75	0.000	0.927	1.326
77	0.000	0.908	1.373
79	0.000	0.887	1.360
81	0.000	0.862	1.390
83	0.000	0.000	1.284

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